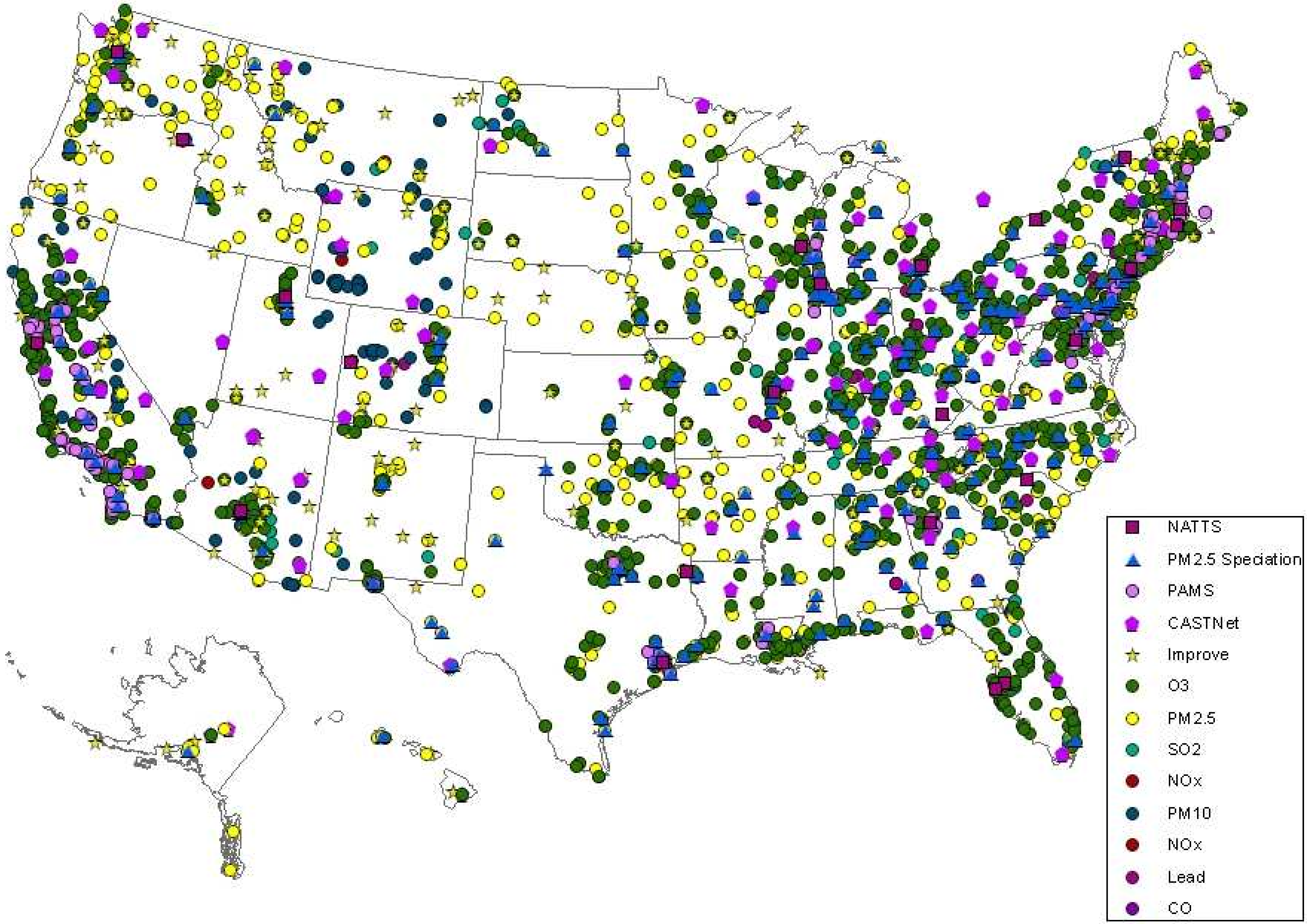
We do quite a bit of surface level ambient air monitoring

NO_2 and satellites

Ambient Air Monitoring Stations in the US



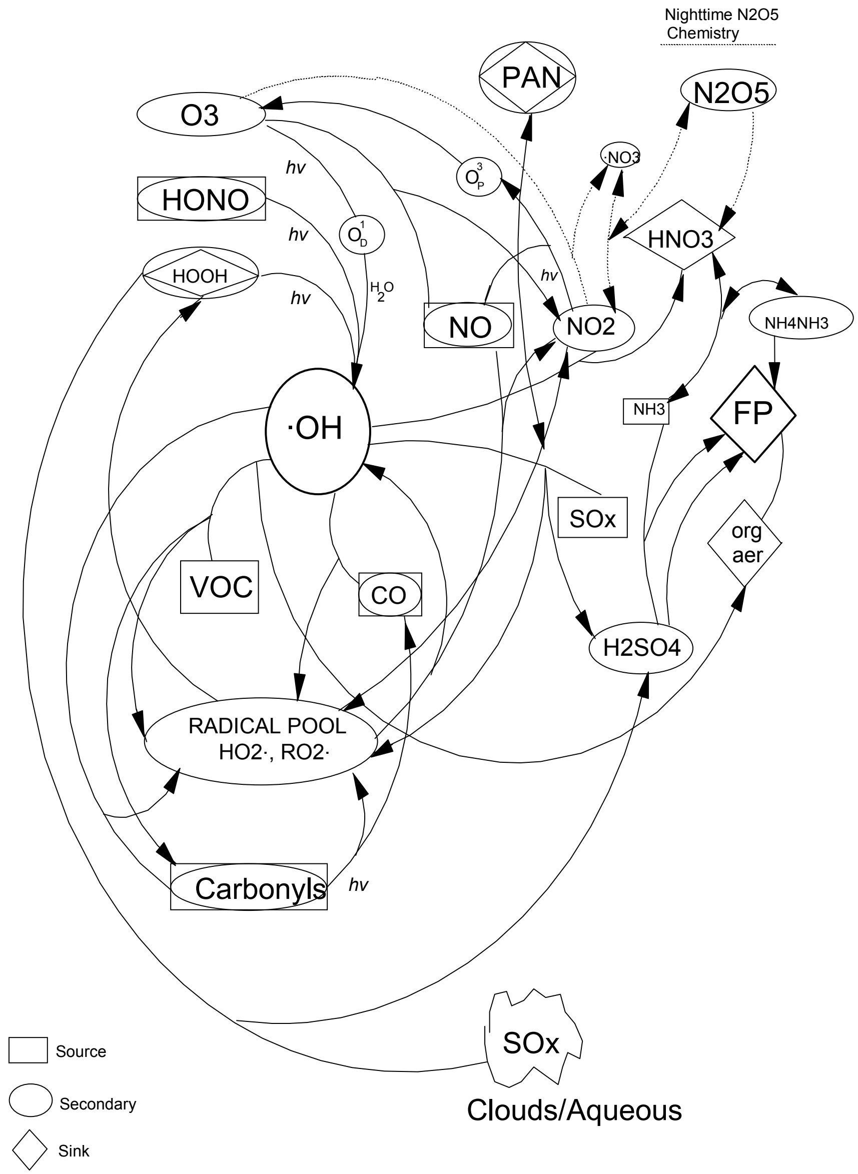
We do quite a bit of surface level monitoring

But we don't measure NO_2 accurately

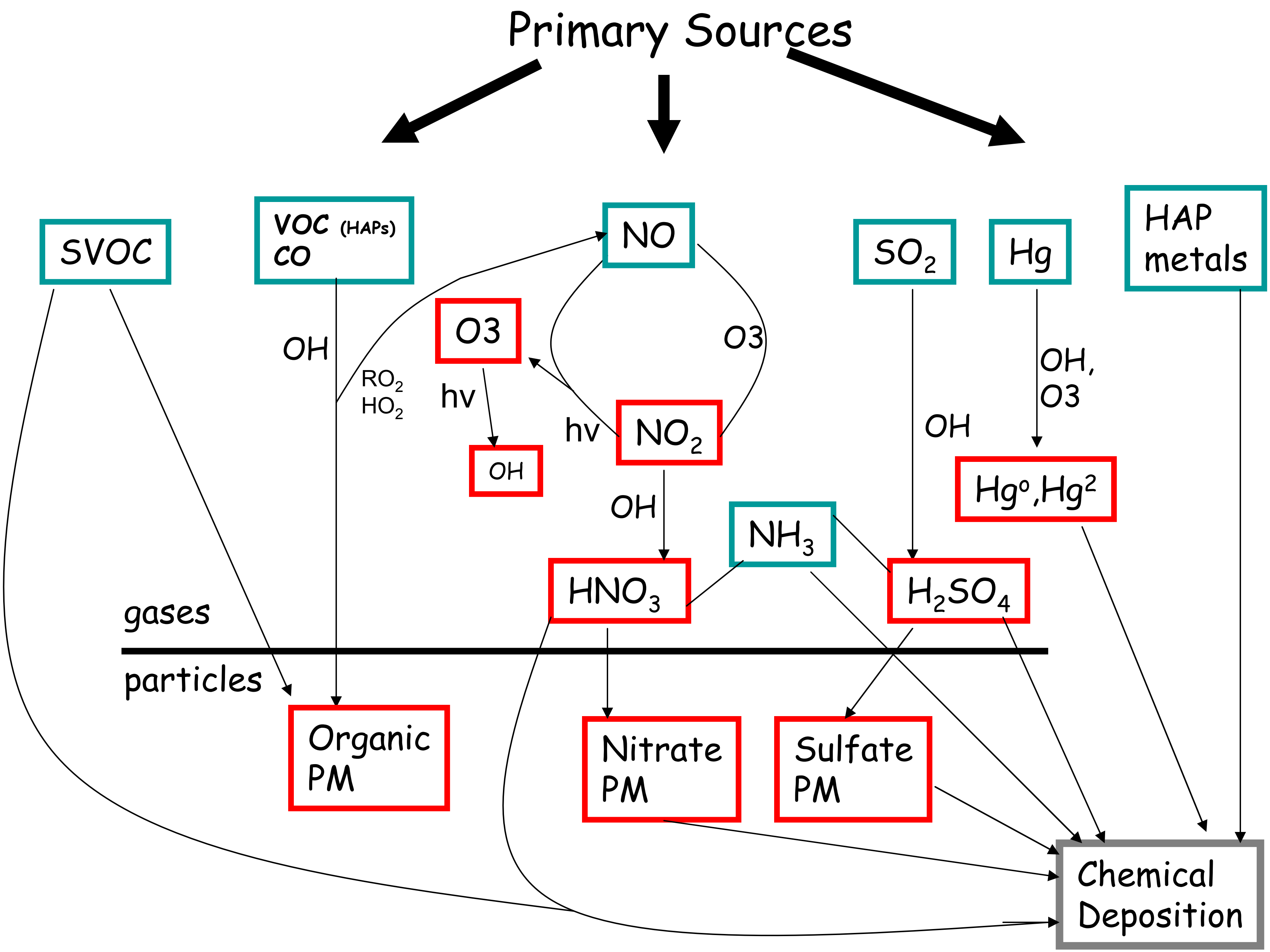
- Routine network NO_2 is determined by chemiluminescence techniques and subject to interference from oxidized N species (e.g., PAN, nitric acid) craeting a variable positive bias in reported NO_2.
  - Demerjian, K.L., 2000; Dunlea et al, 2007
- Alternative techniques TILDAS and DOAS are deployed in special field campaigns; a reliable routine true NO_2 monitor is under development
- Consequently, satellites provide some of our best "pattern" information on NO_2
- Unfortunately, limited ground based ground truthing capability for satellites

Why do we care about NO_2

- Key diagnostic of basic atmospheric chemistry processes
- The focus of national and regional U.S. emissions reduction strategies late 1990's through 2020
  - NOx SIP CALL
  - CAIR
  - Mobile source rules
- Role in N mass balances important for deposition and ecosystem assessments
  - E.g., Current NOx/Sox secondary standard review



Nighttime N2O5
Chemistry
PAN
N2O5
O3
hv
·NO3
HONO
hv
HNO3
HOOH
hv
NO
hv
NO2
NH4NH3
·OH
NH3
FP
SOx
VOC
org
aer
CO
H2SO4
RADICAL POOL
HO2·, RO2·
Carbonyls
hv
SOx
Clouds/Aqueous
Source
Secondary
Sink



Primary Sources
SVOC
VOC (HAPs)
CO
NO
SO2
Hg
HAP
metals
OH
RO2
HO2
O3
hv
OH
hv
O3
NO2
OH
OH,
O3
OH
Hg°,Hg2
OH
NH3
HNO3
H2SO4
gases
particles
Organic
PM
Nitrate
PM
Sulfate
PM
Chemical
Deposition

Practical applications of satellite NO_2

- Emission Inventory Improvement
  - Constraining emissions, especially in regions with poorly characterized inventories
    - e.g., India, Asia
    - Lightning and soil NOx
- Air quality Model Evaluation
  - Constraining total column NO_2
- Accountability -Tracking progress of emission reductions/trends
- Boundary value development and evaluation (global models)
  - Conceptual views of N transport
  - Critical to O3 planning, especially with reduced standards
- Surface complements
  - Potential gap filling
- Examples:

Accountability and Trends

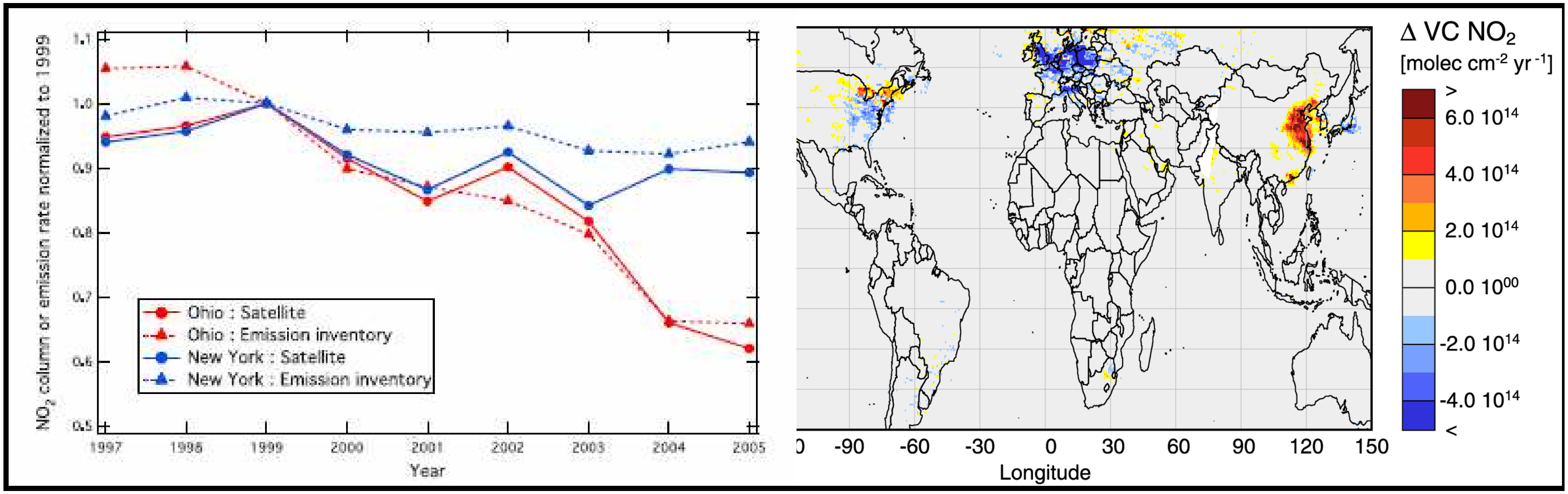


Figure 20. Left - **s**uperimposed Eastern U.S. emission and combined GOME and SCIAMACHY NO2 1997-2002 trends (Kim et al., 2006); right - GOME NO2 trends from 1995 – 2002 (after Richter, 2005). Clear evidence of reductions in midwest U.S. and European NOx emissions, and increased NOx generated in Eastern Asia.

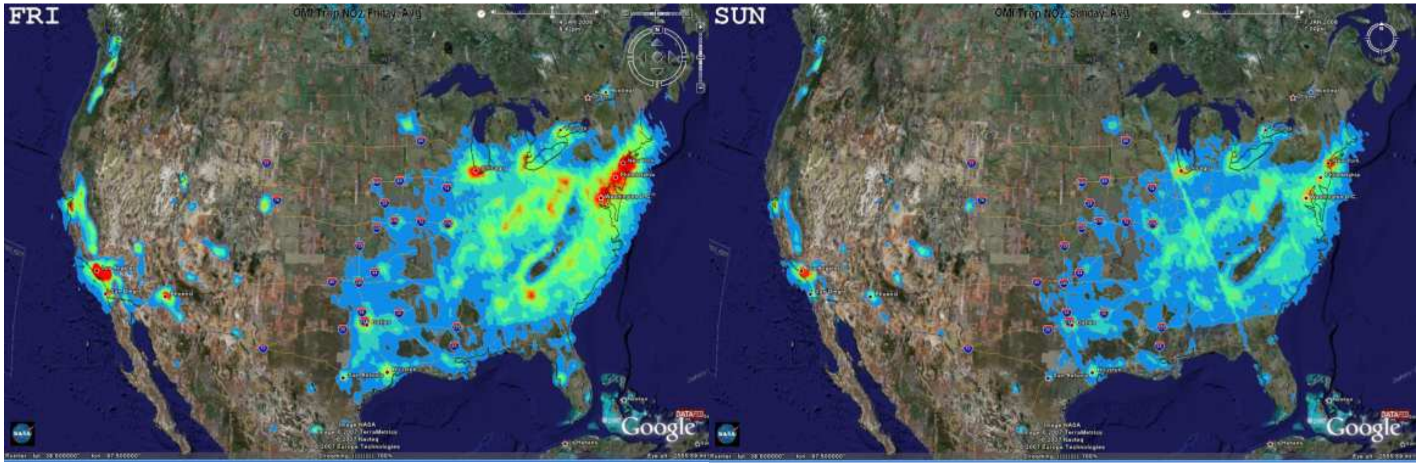
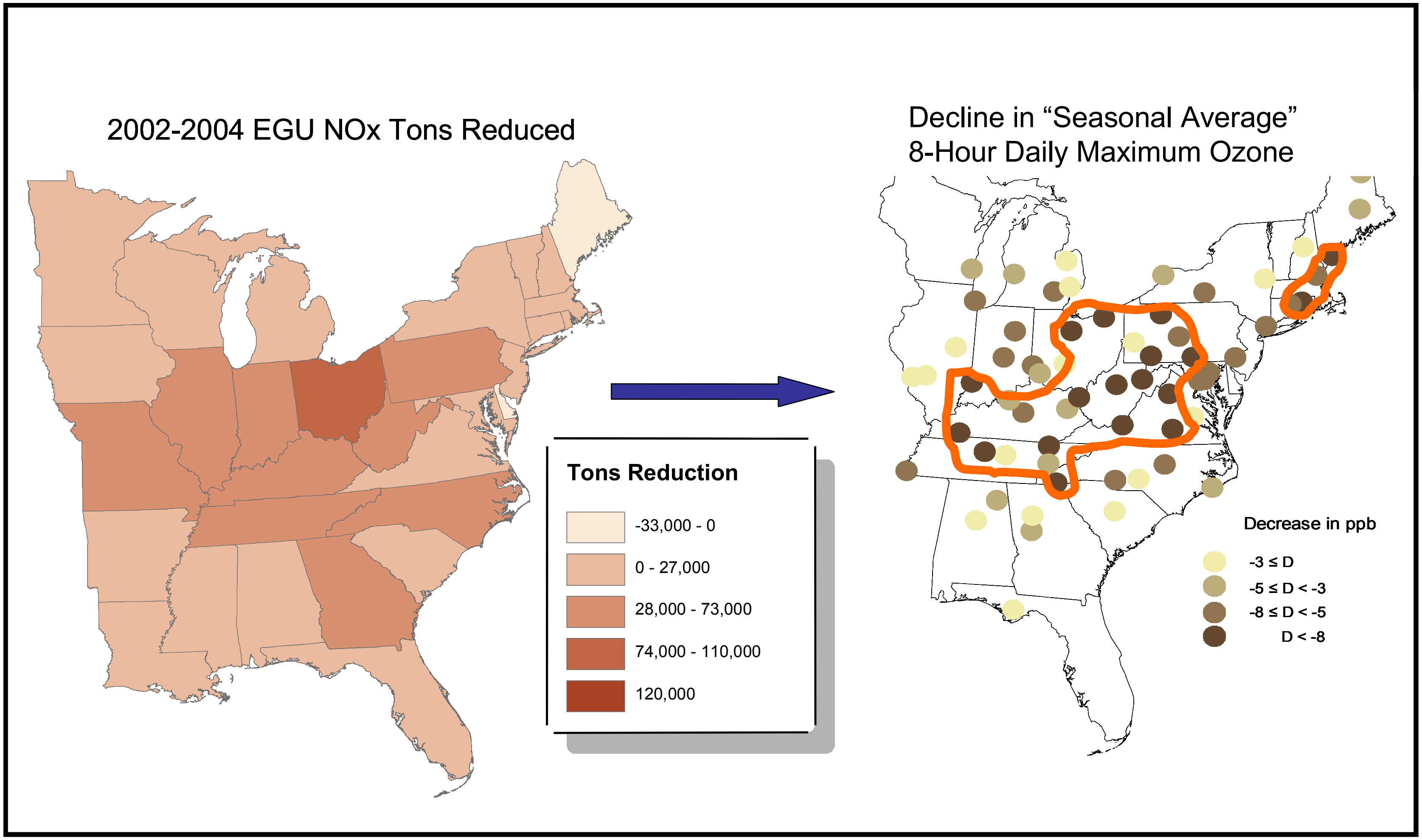


Figure 21. 2004 OMI NO2 column images aggregated for all Fridays (left) and Sundays (right) indicating weekend/weekday patterns associated with reduced Sunday emissions (source, Husar).

EPA assessment of NOx SIP CALL missing N measurements

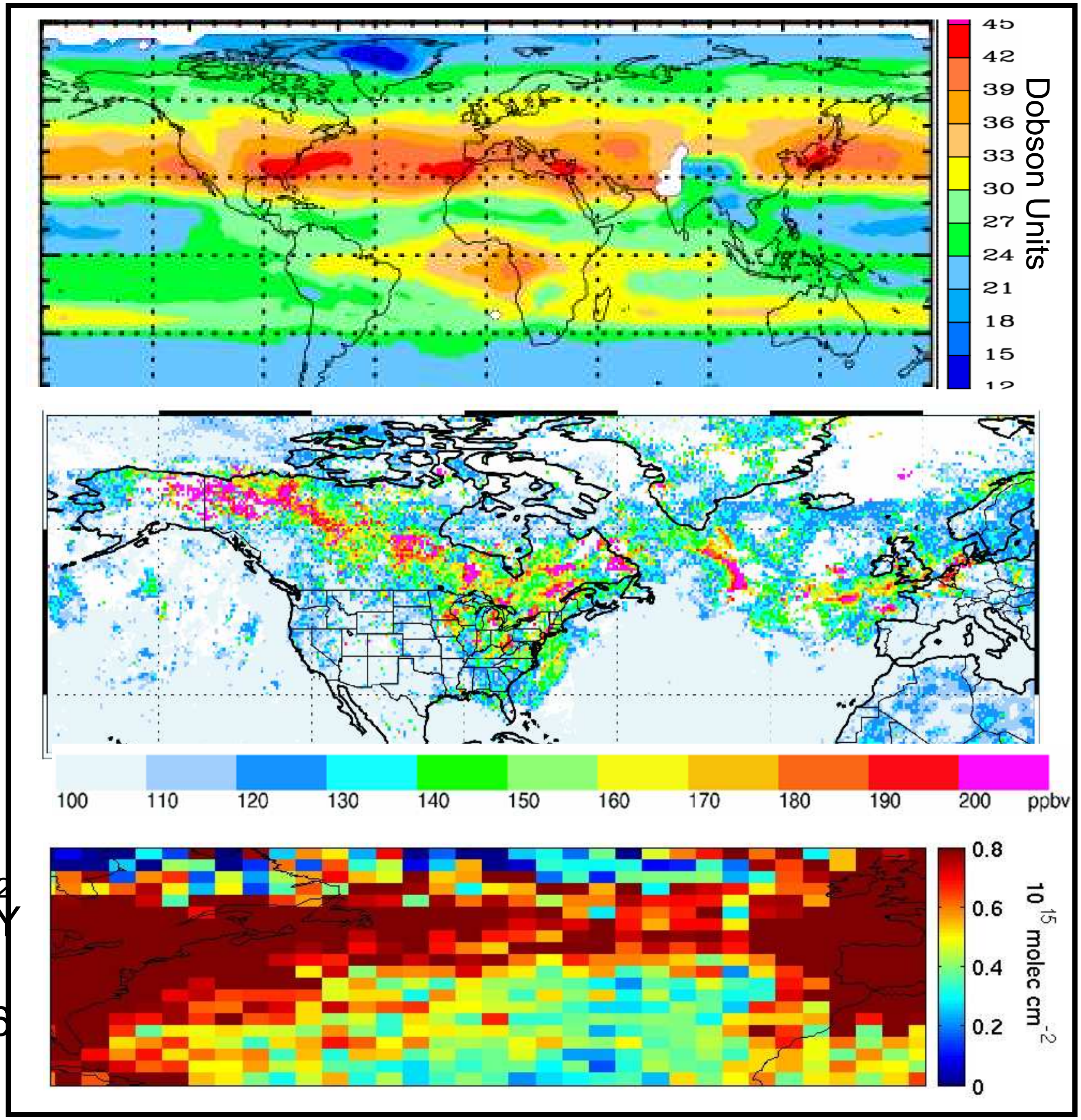


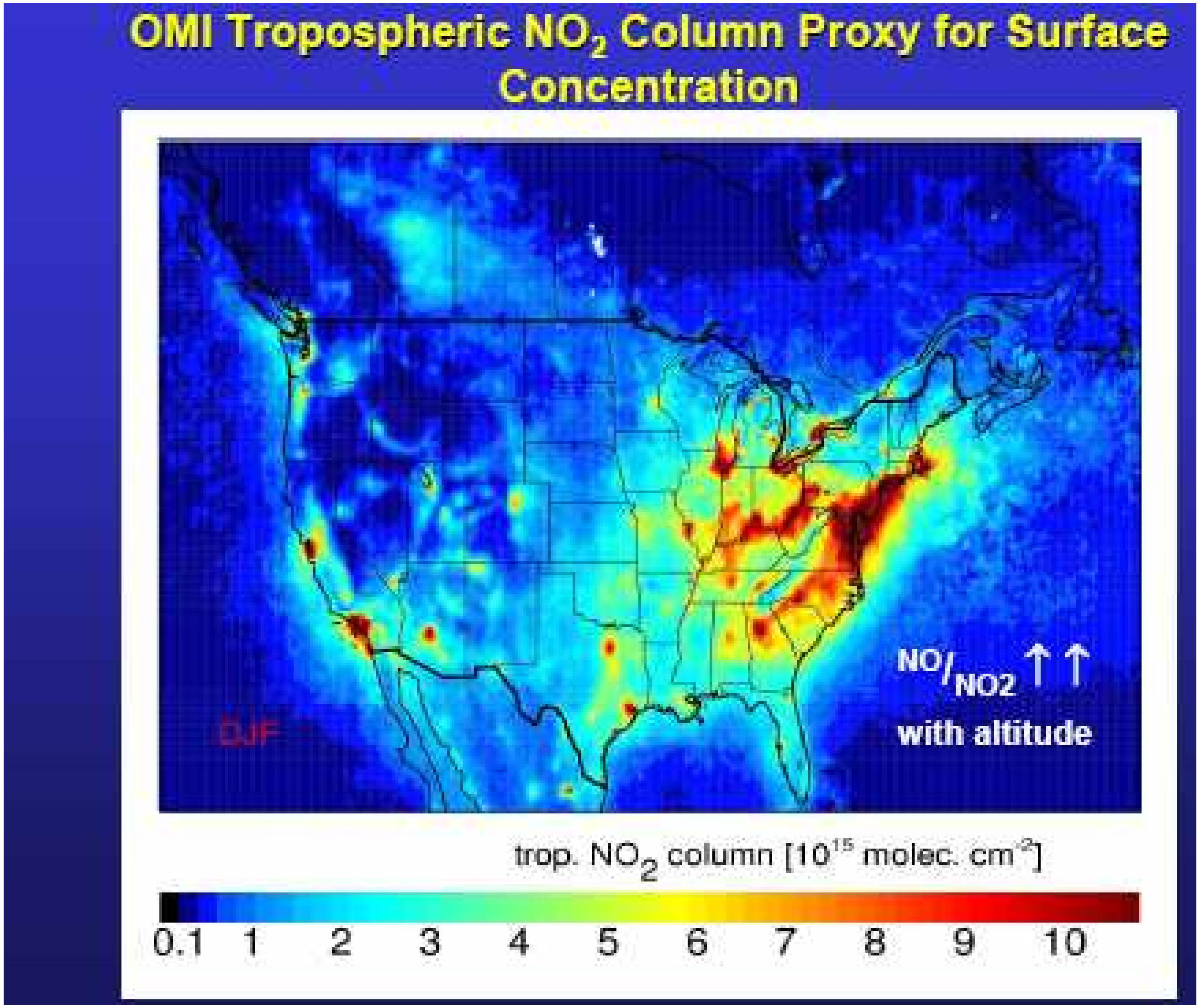
Transport Evidence from Satellites: Ozone, CO and NO_2

Tropospheric O_3
from GOME for
summer 1997
Liu et al., 2006

CO from MOPITT
for July 2004
Pfister et al., 2006

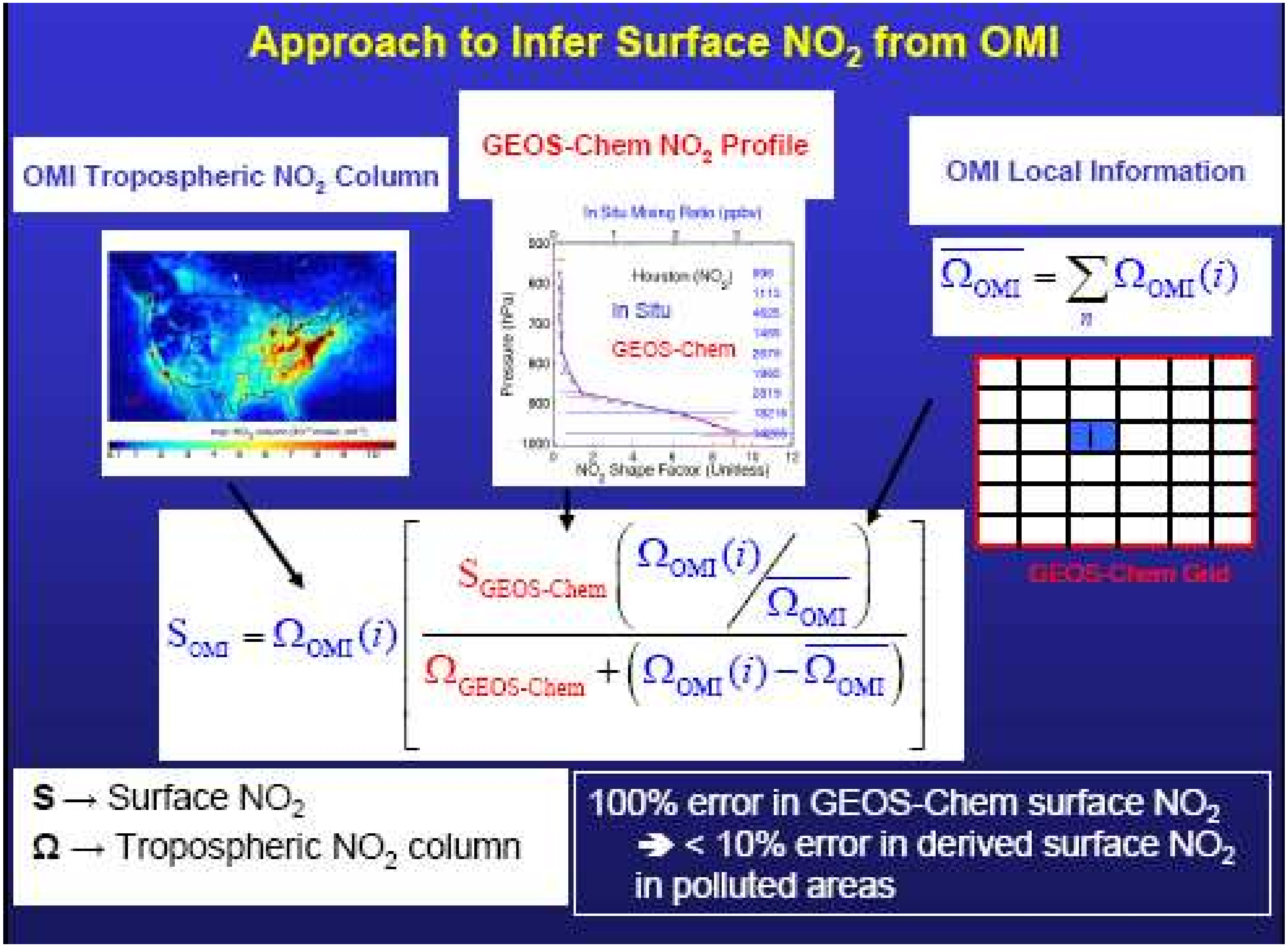
Tropospheric NO_2
from SCIAMACHY
for summer 2004
Martin et al., 2006





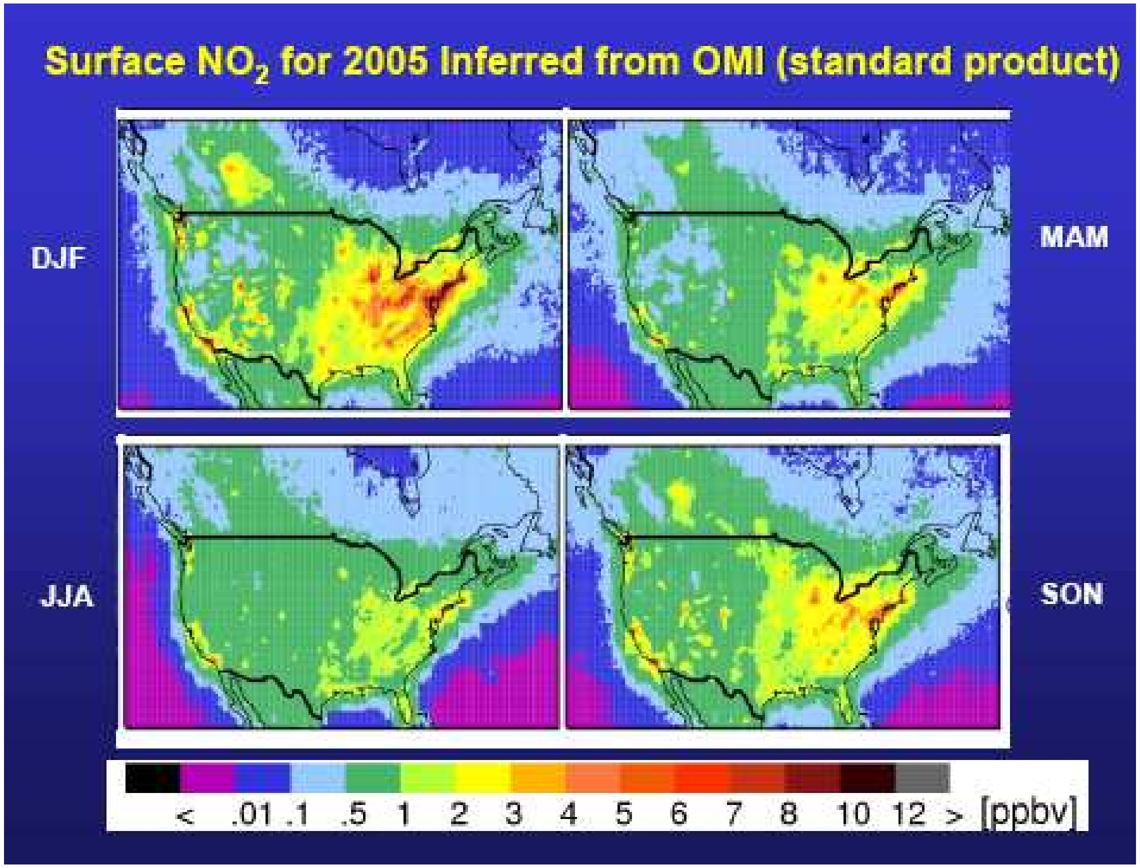
(Courtesy, Randall Martin)

Inferring surface texture through modeled characteristics, R. Martin



$$\overline{\Omega_{OMI}} = \sum_{n} \Omega_{OMI}(i)$$

$$S_{OMI} = \Omega_{OMI}(i) \left[\frac{S_{GEOS\text{-}Chem}\left(\Omega_{OMI}(i) / \overline{\Omega_{OMI}} \right)}{\Omega_{GEOS\text{-}Chem} + \left(\Omega_{OMI}(i) - \overline{\Omega_{OMI}} \right)} \right]$$



(Courtesy, Randall Martin)

Satellite HCHO data…isoprene surrogate for natural emissions

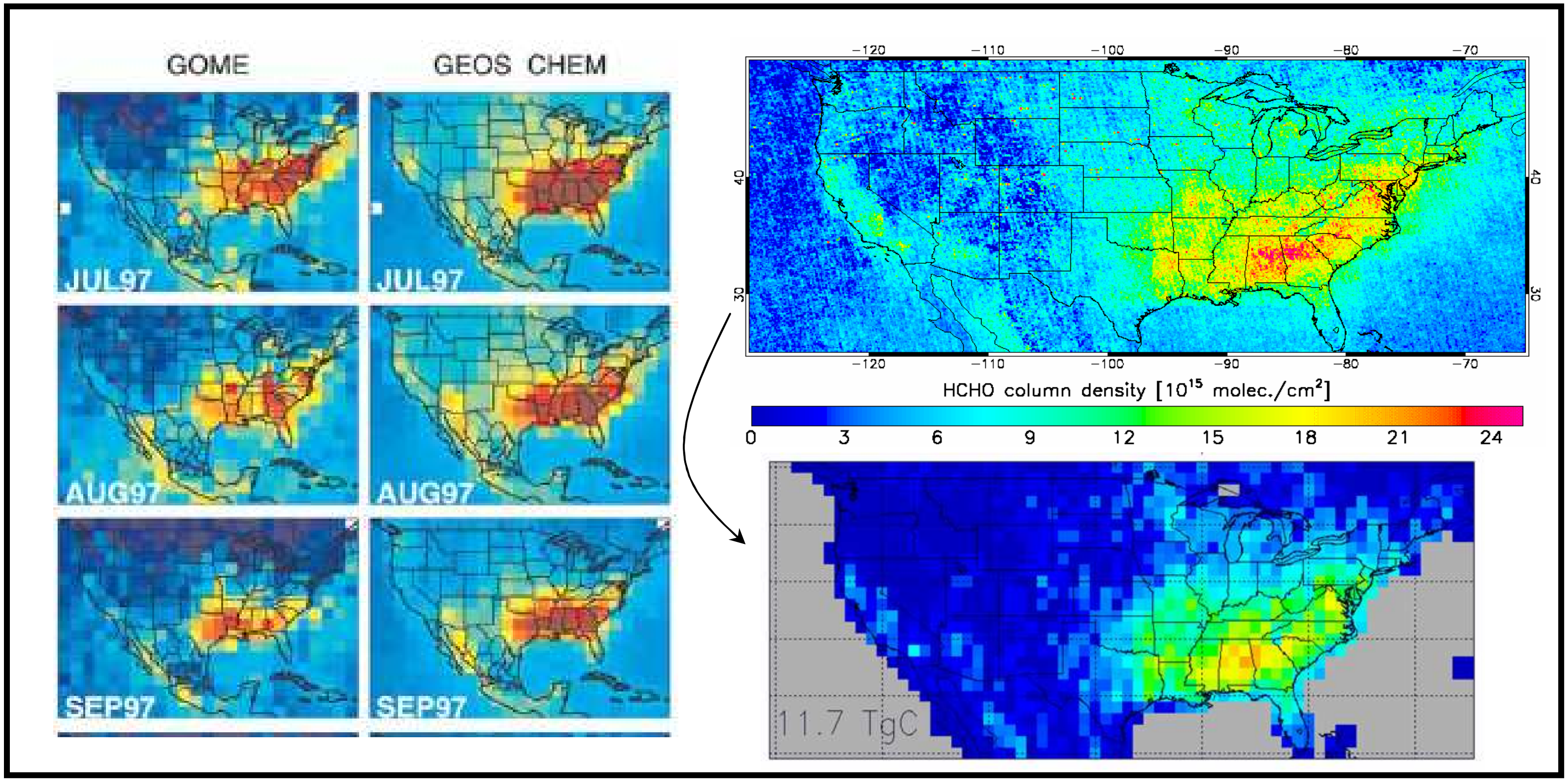


Figure 19. Left – Comparisons between GEOSchem global model and GOME derived formaldehyde fields (Abbott et al. 2003);Right – Summer 2006 OMI column HCHO and translation to isoprene emission estimates (Miller et al., 2007).

EXTRAs

Start with….

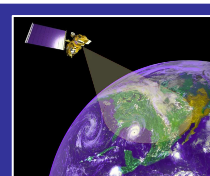
- A simple overarching goal or vision,

  - Strive for maximum and efficient AQ characterization in time, space and compositional terms

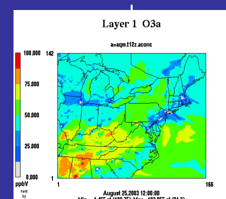
- the intersecting or common link between air programs and satellite data and integrated advanced systems

TGAS/Aerosol Satellite Measurements and Numerical Predictive Models

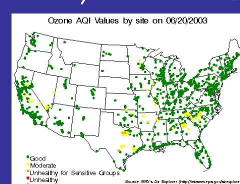
- Integration of systems to improve
  - air quality models for forecast
  - Current and
  - Retrospective assessments
- Global-Regional Air Quality Connections
- Climate-AQ connections



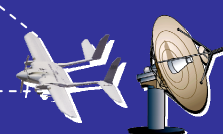
Total column depth (through Satellites)



AQ model results



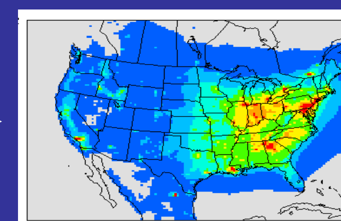
Land AQ Monitors



Vertical Profiles

<u>Integrated Observation- Modeling</u>

Optimized PM2.5, O3



Characterizations

Health

Air management

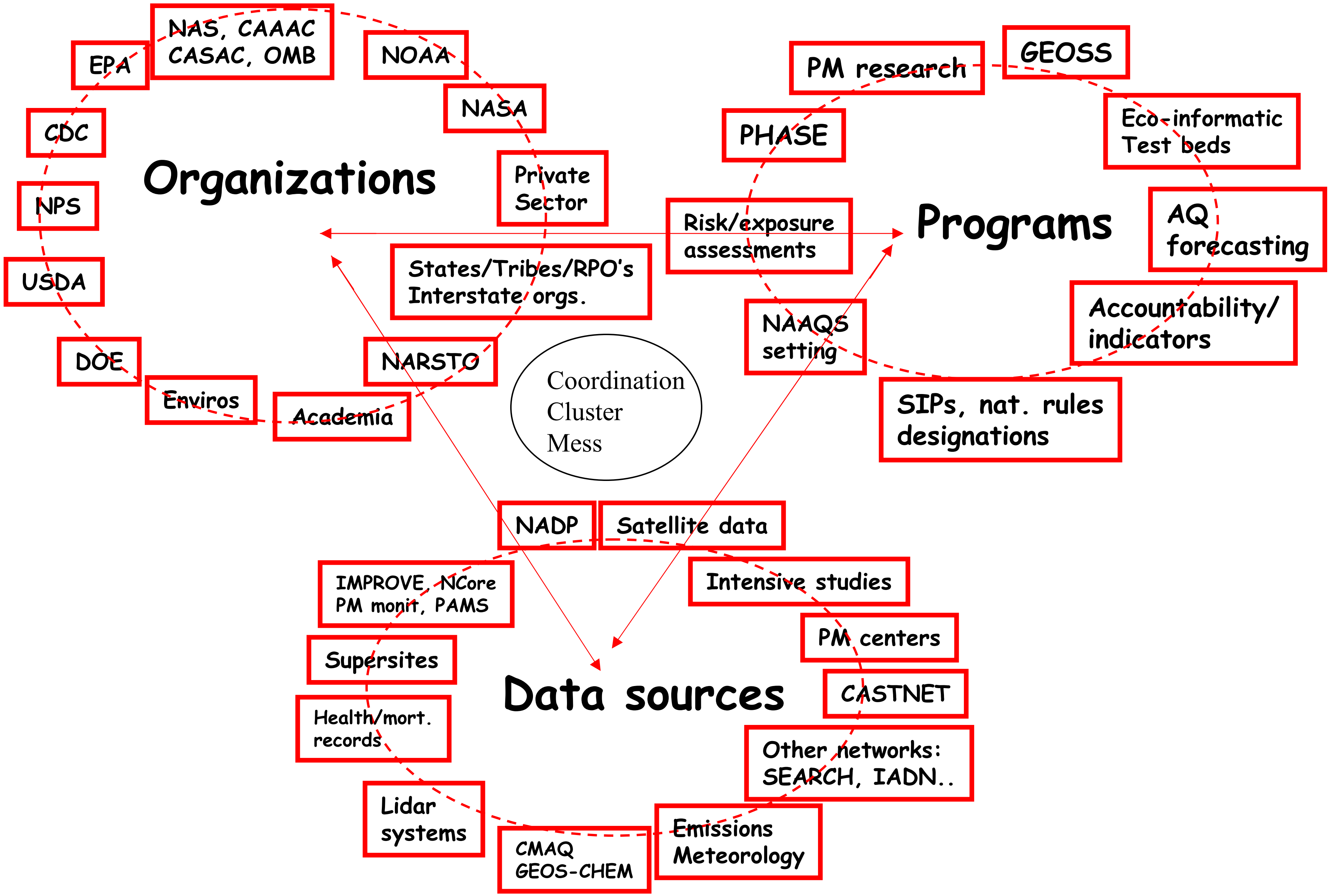
ecosystems

Using “characterization” as a driver, …consider

- Integration of observations and modeling logically is more critical than observations alone; might imply priority on
    - Inverse emissions generation
    - “data assimilation”
    - Observation gap filling an input to above
        - Lower expectations of replacing in-situ observations
- Vertical characterization severely neglected (most mass is well above the surface)
- NASA supported outreach providing conceptual pictures/models is a major contribution filling a gap
    - Smog blog
    - IDEA

How serious (re: partnerships) are agencies

- Technical collaboration is happening
- Opportunities remain/missed?
  - Ground surface complement to leverage total column data
    - NASA dedicated resources in linking column and vertical observations to surface data
    - EPA/States/USDA/USGS/DOI rest on established networks
      - Suggestions: in situ HCHO, trace gases (SO_2, CO, NO_2) to evaluate OMI
      - EPA Sustain Brewer UV network
      - Aggressive NH_3 and Hg monitoring (space complements not available
      - Integrated multi-agency strategy development


Organizations
NAS, CAAAC
CASAC, OMB
EPA
NOAA
NASA
CDC
NPS
USDA
DOE
Enviros
Academia
NARSTO
States/Tribes/RPO's
Interstate orgs.
Private
Sector
Programs
PM research
GEOSS
PHASE
Eco-informatic
Test beds
Risk/exposure
assessments
AQ
forecasting
NAAQS
setting
Accountability/
indicators
SIPs, nat. rules
designations
Coordination
Cluster
Mess
Data sources
NADP
Satellite data
IMPROVE, NCore
PM monit, PAMS
Intensive studies
Supersites
PM centers
CASTNET
Health/mort.
records
Other networks:
SEARCH, IADN..
Lidar
systems
CMAQ
GEOS-CHEM
Emissions
Meteorology

Bridging atmospheric science-IT worlds

- EPA/NASA/NOAA IT systems
- US GEO role?
- Building the ESIP, DataFED concepts into a working system accessible and usable by the non expert community
  - Lessons from WMO/GAW, GEMS, GIOVANNI, VIEWS

Thank You!